Environmental Science & Policy 55 (2016) 135–140

Contents lists available at ScienceDirect

Environmental Science & Policy

journal homepage: www.elsevier.com/locate/envsci

Short communication

Redefining maladaptation

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ARTICLE INFO

Article history:
Received 2 July 2015
Received in revised form 26 September 2015
Accepted 26 September 2015
Available online 21 October 2015

Keywords:
Climate change
Adaptation
Maladaptation
Vulnerability
Feedbacks

ABSTRACT

As experiences of implementation of climate change adaptation are accumulating, there is a need to increase the understanding of the potential negative consequences of adaptation actions that might occur, and the capacity of research to assess them. Maladaptation used in this context has remained elusively defined and sparingly used, and therefore difficult to apply. Based on a literature review, we discuss the conceptual boundaries of maladaptation and how it can be used to analyse negative outcomes of adaptation and propose a refined definition. We present a typology of maladaptation that distinguishes between three types of maladaptive outcomes – *rebounding vulnerability*, *shifting vulnerability* and *eroding sustainable development*, and argue that maladaptation can be defined as *a result of an intentional adaptation policy or measure directly increasing vulnerability for the targeted and/or external actor(s), and/or eroding preconditions for sustainable development by indirectly increasing society's vulnerability*. We note that the recognition of adaptation as an intentional action and the importance of setting clear spatial and temporal boundaries, as well as thresholds, are key to analysing negative outcomes.

1. From adaptation to maladaptation

The need for adaptation to climate change has been widely recognised (Pielke et al., 2007; IPCC, 2007, 2014), and the study of adaptation as a social process has generated a field of research that is rapidly accumulating (Smit et al., 2000; Kelly and Adger, 2000; Adger et al., 2005; Smit and Wandel, 2006; Gallopín, 2006; Füssel, 2007a,b; Ford et al., 2011). This development can be characterised with a move from impact-led research towards a better understanding of social processes that underlie the ability of societies to adapt to the consequences brought about by climate change (Burton et al., 2002).

Progress has also been made in terms of implementation which can be exemplified by the national adaptation strategies developed by several countries (Biesbroek et al., 2010). The literature on the outcomes of adaptation has primarily asked how successful adaptation actions have been in relation to equity, efficiency and legitimacy (Adger et al., 2007). It has also centred on comparisons of national or local approaches, and more recently on the identification of barriers and limits to adaptation (Adger et al., 2009; Moser and Ekstrom, 2010; Biesbroek et al., 2013), whilst less effort has been put into studying the effects of implemented adaptation policy and measures (Klein and Juhola, 2014). As experiences of implementing adaptation are accumulating at a rapid pace, there is a need to increase the understanding of the potential negative consequences of adaptation actions.

The concept maladaptation has been proposed to study the outcomes of adaptation that fail to reduce climate-related risk, or that generate negative consequences for others. One of the earliest attempts to systematically conceptualise maladaptation emerged from Barnett and O'Neill (2010) and others have followed since. Recognising the early mentions of the concept by Smit (1993) and Burton (1997) in the 1990s, Barnett and O'Neill define maladaptation to be 'action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, or increases the vulnerability of other systems, sectors or social groups' (Barnett and O'Neill, 2010: p. 211). The authors further point to five different types of maladaptation that can arise in the form of (1) increasing GHG emissions, (2) disproportionately burdening the most vulnerable, (3) high opportunity costs, (4) reducing incentives to adapt, and (5) path dependency.

Within this rapidly increasing research field, empirical studies highlighting maladaptation have emerged in the recent years. However, despite the unspoken recognition that not all adaptation

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http://dx.doi.org/10.1016/j.envsci.2015.09.014
1462-9011/

actions will be successful, the concept of maladaptation has remained sparingly used and elusive, as recognised by the IPCC, which has made it difficult to apply as an analytical concept for studying outcomes of adaptation policy (Noble et al., 2014). In this paper, we revisit the definitions of maladaptation to explore its potential as an analytical and operational concept. To do this, we present a review of this literature in the form of a typology and identify key elements in order to make it analytically distinct and operationally apt.

2. A review of recent literature

With regards to maladaptation, the IPCC states that '[T]he adaptation literature is replete with advice to avoid maladaptation, but it is less clear what is precisely included as "maladaptation"' (Noble et al., 2014: p. 28). These difficulties stem from a number of sources. Granberg and Glover, for example, argue that '. . .there are neither widely accepted criteria nor yardsticks that have been developed to identify maladaptation' (2013: p. 4). Furthermore, in addition to the varying local circumstances and the passage of time, the authors argue that identifying maladaptation is also plagued by problems of subjective judgement.

When thinking about maladaptation, it is crucial to consider the definition of adaptation, given the reciprocity of the two concepts. The IPCC's Fifth Assessment Report (AR5) defines adaptation as a 'process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects' (AR5, glossary).

The Fourth Assessment Report (AR4) clarified the intent behind this adjustment (planned vs. autonomous). Planned adaptation is 'the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state' (AR4, glossary). The Fifth Assessment Report (AR5) further defined autonomous adaptation to be in response to experienced climate and its effects, without planning explicitly or consciously focused on addressing climate change" and it is also referred to as "spontaneous adaptation' (AR5, glossary).

Maladaptation, according to AR5, is 'a cause of increasing concern to adaptation planners, where intervention in one location or sector could increase the vulnerability of another location or sector, or increase the vulnerability of the target group to future climate change' (AR5, glossary). Whilst the IPCC highlights the urgency of focusing on the negative consequences of adaptation, their definition does not go far in making it analytically distinct or to operationalise it for further research and practice to study negative outcomes.

A body of literature has emerged since 2010 that discusses numerous empirical examples of maladaptation, providing an opportunity to assess what has, and has not, been included in the analyses of maladaptive outcomes. In this literature review,[1] we collected these latest empirical examples of maladaptation in the scientific literature. We used this research as the basis of our conceptual work because it enables us to compile and structure practical examples of maladaptation presented to date, rather than relying on a smaller sample. A majority of the studies reviewed for this paper are various forms of case studies conducted on different scales – stretching from national to individual level. The studies are based in various continents, cover various sectors, with majority focusing on agricultural and urban planning.

We group the examples of maladaptive outcomes in these studies using a simple typology approach. In scientific research, a typology is a way of classifying and organising phenomena into distinct types (Ziemski, 1975). In this categorisation of the literature, we used the negative feedback loops of adaptation as our organising method. This is what the widely used definition by Barnett and O'Neill refers to as 'the impacts adversely affect other systems, sectors or social groups' (Barnett and O'Neill, 2010). We further divided these feedbacks based on who or what is affected and in what way. Hence, we deduce that three types of maladaptation can be identified: (1) rebounding vulnerability, (2) shifting vulnerability and (3) eroding sustainable development (Table 1).

Rebounding vulnerability is a simple connection implying an adaptation action that increases current or future climate change vulnerability of the implementing actor (or the targeted actor(s) if implemented by e.g. a local government). The actor(s) can be affected in three different ways; through increasing exposure; or increasing sensitivity; or by decreasing the actors' adaptive capacity.[2] Many of these studies analysed the negative feedbacks within small communities, emphasising how adaptation can lead to adverse impacts locally. The temporal aspect was considered to be important here. For example, a short time perspective on adaptation can lead to decreased adaptive capacity and hinder future choices (Ford et al., 2013).

Shifting vulnerability increases current or future vulnerability for one or several external actors. The external actors' vulnerability can be affected through increased exposure or sensitivity, or by decreased adaptive capacity. Many of these examples emerge from larger-scale adaptation actions where increased vulnerability has a spill-over effect in other locations. Examples of these include effects of coastal structures that may cause erosion elsewhere (Grothmann and Patt, 2005), or when a development of desalination plants to adapt to drinking water deficiency leads to disproportionately high cost for low income water users (Barnett and O'Neill, 2013; McEvoy and Wilder, 2012).

Eroding sustainable development is an outcome of an adaptation action that increases GHG emissions and negatively impacts environmental conditions and/or social and economic values. These side effects are presented as negative for society as a whole without singling out affected actors, creating common pool problems. The studies concentrate on the effects of adaptation that undermine the base on which adaptation relies. Essentially, the focus here is on negative feedbacks that occur on a global scale, undermining the conditions for sustainable development. Many of the examples of maladaptive actions increase GHG emissions, which consequently exacerbate climate change and hence cause the need for more adaptation (Hopkins, 2014; Andersson-Sköld et al., 2015; Beilin et al., 2011; Brown, 2011; Adger et al., 2010).

3. Applying the maladaptation concept – elements to consider

The above typology reflects the way in which the concept has been used in the literature in recent years. It raises a number of interesting questions when placed next to the existing definitions of maladaptation. The IPCC AR5 definition and the one offered by Barnett and O'Neill and our typology based on the review of the

[1] Literature review: search in Scopus for "maladaptation and Climate Change" resulted in 66 articles. 22 of these articles were found relevant for the analysis based on initial assessment of keywords search. These were complemented with papers about maladaptation cited in IPCC (WGII, AR5, chapter 14) and within the found articles. In total 31 papers were analysed in depth.

[2] Definitions of Vulnerability and its dimensions according to the IPCC AR5 Glossary (Agard et al., 2014): "Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt."

Table 1
Types of maladaptation.

Maladaptive outcome	Effect	Examples	References
Rebounding vulnerability (for implementing/ targeted actor(s))	Increased exposure	Trees planted to provide shade that damage buildings in case of a storm	Glaas et al. (2015)
	Increased sensitivity	Introduction of new tree spices to cope with climate change that increases sensitivity	Benito-Garzón et al. (2013)
	Decreased adaptive capacity	Ineffective beach nourishment and coastal defence systems that adds costs without lowering vulnerability	Thomsen et al. (2012), UNFCCC (2007)
		"Hard" infrastructure (e.g. sea walls) that reduces flexibility of future adaptation options	Adger et al. (2003), Eriksen and Kelly (2007), OECD (2009)
		An preoccupation on avoiding the impacts associated with a single projection of sea level rise that lead to deterministic and cost-inefficient responses	Macintosh (2013)
		Overspecialisation of Inuit communities to cope with climate change in a short time perspective that negatively effects adaptive capacity in a long time perspective	Ford et al. (2013)
		Resettlement of small island state inhabitants leading to lower adaptive capacity due to unemployment, homelessness, landlessness, food insecurity, social marginalisation, reduced access to common-property resources and increased morbidity	Barnett and O'Neill (2012)
	Undefined	Current responses to weather variability that are maladaptive to climate change effects in the longer term	Mycoo (2014), Richards and Howden (2012), Brooks et al. (2010)
Shifting vulnerability (to external actor(s))	Increased exposure	New climate resilient roads that increases vulnerability in new settlements in the future	Lamhauge et al. (2011)
		Re-engineering of household lots that accelerated the rate of surface run-off into an already incapacitated drainage system.	Mycoo (2014)
		Coastline armouring or infrastructure that leads to coastal erosion elsewhere	Grothmann and Patt (2005)
	Increased sensitivity	Development of floodplains leading to reduced buffering capacity for river water	Klein et al. (2007)
	Decreased adaptive capacity	Investments in power grids leading to increased prices on power, decreasing adaptive capacity among vulnerable groups	Quezada et al. (2014)
		Development of desalination plants to adapt to drinking water deficiency leading disproportionately high cost for low income water users	Barnett and O'Neill (2013), McEvoy and Wilder (2012), Barnett and O'Neill (2010)
Eroding sustainable development (common pool problem)	Increased GHG emissions	Development of artificial snow for skiing that increases GHG emissions	Hopkins (2014)
		Adaptation actions leading to increased GHG emissions and environmental degradation	Andersson-Sköld et al. (2015), Beilin et al. (2011), Brown (2011), Adger et al. (2010)
		Investments in power grids leading to technology lock-ins into power generation alternatives for end-users (PV, petrol and diesel run machines etc.)	Quezada et al. (2014)
		Development of desalination plants to adapt to drinking water deficiency leading to increased GHG emissions	Barnett and O'Neill (2013), McEvoy and Wilder (2012), Barnett and O'Neill (2010)
	Environmental degradation	Adaptation measures having negative impacts on freshwater ecosystem services.	Pittock (2011)
		Water grabs from shared surface or groundwater resources with poorly defined property rights	Olmstead (2013)
		Irrigation that lead to salinisation of groundwater and degradation of wetlands	Klein et al. (2007)
		Wood heating to make households less vulnerable to power outages leading to smog and negative respiratory health effects	Bélanger et al. (2008)
	Negative economic and social externalities	Adaptation actions leading to market failures including market externalities, collective goods problems, principal agent problems and the absence of knowledge for decision-making	Granberg and Glover, (2013: p. 10)
		Resource concentration, land grabbing, aggrevated social poverty	Sovacool et al. (2015)

literature share some similarities but some differences can also be observed.

First, all three definitions appear to acknowledge that maladaptation occurs when there are negative feedbacks that increase vulnerability. The two definitions do not explicitly distinguish between the implementing actor and others who may be affected by the actions. The IPCC definition of maladaptation states that "the intervention in one location or sector could increase the vulnerability of another location or sector", while Barnett and O'Neill (2010, p. 212) define it as adversely "burdening the most vulnerable". However, the reviewed literature revealed a more nuanced distinction between affected actors or sectors. Hence, it is possible to further differentiate between impacts on the implementing actor, i.e. *rebounding vulnerability*, and transferring the negative effects to someone else, or what we have termed as *shifting vulnerability*.

All three definitions also acknowledge that maladaptation has a temporal dimension. The IPCC definition describes this as increasing the vulnerability of groups in the future whereas Barnett and O'Neill discuss the increase in GHG emissions that further exacerbates climate change. We have termed this as *eroding sustainable development* whereby the conditions to continue to thrive are being compromised.

However, there are also differences in the three definitions of maladaptation that can be observed based on the accumulated literature on the matter. First of all, increased opportunity costs

appear not to be recognised in the reviewed literature. Barnett and O'Neill, on the other hand, define actions that have high opportunity costs, including economic, environmental or social, as maladaptation (Barnett and O'Neill, 2010). They cite examples of projects related to water desalination where better outcomes could have been achieved with less costly options and without causing additional environmental harm.

Second, Barnett and O'Neill also consider actions that reduce incentives for adaptation maladaptive. Here, the authors argue that there are adaptation measures that can reduce adaptive behaviour. For example, two adaptation options might support the same goal but with the other not addressing the underlying cause for the need for adaptation. However, the literature does not consider the weighing of adaptation incentives as a criterion of maladaptation.

Finally, Barnett and O'Neill highlight the fact that path dependency can lead to maladaptation, which had largely gone unnoticed in the literature. Here, certain adaptation decisions can lead to trajectories that are difficult to change, i.e. large infrastructure projects, such as the Santa Barbara desalination plant (Barnett and O'Neill, 2010).

After reviewing the literature, we continue to find ambiguity in the way the concept is used, which is limiting its application. Specifically, we have identified key elements which might be important to address when designing analyses of maladaptation – in order to enhance its analytical value and operational strength – posed here as three separate questions: (i) is the maladaptation an outcome of an adaptation action or a maladaptive process?; (ii) what are the system boundaries, including temporal and spatial scale?; and (iii) how are thresholds of maladaptation defined? These elements can be used to guide the application of the concept.

3.1. Is maladaptation an outcome of an adaptation action or a maladaptive process?

We found a disparity in the literature on what specifically maladaptation was a negation of. Adaptation as a noun could refer to: (a) the act of adapting, (b) the state of being adapted, or (c) the outcome achieved by adapting. So, there is a need to distinguish between whether the concept refers to potentially maladaptive processes, the state of being adapted in a way that generates negative feedback loops, or an outcome from adapting that entails negative feedback loops. If maladaptation is used in the first two instances, the whole process or state will be deemed to be inherently negative for adaptation outcomes. This is rarely the case in the literature. However, in any case, the assessment will fall back on expected or actual outcomes.

3.2. What are the system boundaries, including temporal and spatial scale?

As several of the reviewed studies indicate, the identification of maladaptive outcomes or processes depends on a distinct definition of system boundaries, including the geographical and temporal scales of the study. As such, the outer boundaries – defining what elements or entities are included in the assessment – can refer to both geographical and administrative units, as well as distinct social and cultural entities, or sectors that are of relevance in the analysed process. The identification of the main object(s) of the study, as well as the interlinkages between these physical and social entities, become of great importance when assessing the risk of maladaptation.

The temporal dimension is important when analysing adaptation actions since its outcomes span across timescales. Specific adaptation actions might have a short-term positive impact, while resulting in negative outcomes in the long term (e.g. Andersson-Sköld et al., 2015; Mycoo, 2014; Brooks et al., 2010) or vice versa. It can be challenging to estimate how long into the future one would need to assess negative feedbacks and whether these have the potential to become positive in the future.

With regards to the spatial scale, a positive outcome of an adaptive action on a local scale could simultaneously imply negative impacts on a regional or a global scale. This has been identified in a number of studies that present adaptation actions with positive outcomes on a local scale, such as the introduction of irrigation schemes (Klein et al., 2007) causing salinisation of groundwater resources and wetland degradation. The identification of maladaptive actions thus requires a broad systems perspective (see Richards and Howden, 2012), as well as a reflexive approach when identifying interdependencies and relationships between actors, sectors and goals. As McEvoy and Wilder (2012: p. 355) argue: 'one group's adaptation may be another group's hazard'. Thus, the recognition of system boundaries and scales are important aspects of identifying maladaptation.

3.3. How are thresholds of maladaptation defined?

The final key question is related to the idea of thresholds when applying the concept. As noted by Granberg and Glover (2013), there are no yardsticks that are widely accepted when discussing the negative outcomes of adaptation. If one is able, as suggested above, to define the boundaries at which one examines maladaptation, there is an intuitive suggestion that not all negative outcomes are equally negative but some are less and some are more.

Therefore, to operationalise the concept, a discussion on thresholds would be needed and consequently an agreement reached as to what those thresholds are within the confines of a specific case study. So far, there are no suggestions in the literature as to how this could be done and there has been no discussion as to what criteria should be used to evaluate how negative the consequences are and for whom, where and when. For example, thresholds can also change with time.

Some cases serve as noteworthy examples, demonstrating the conceptual and methodological challenges associated with thresholds. For example, Barnett and O'Neill discuss a desalination plant in Santa Barbara as an example of path dependency leading to a maladaptive outcome because the technology has not been used since it was built in 1990 and is thus a sunk cost (Barnett and O'Neill, 2010, p. 212). In fact, the Charles E. Meyer Desalination Plant discussed was not utilised beyond a testing period but in a recent decision in July 2015, the city council has decided to open up the plant again (City of Santa Barbara, 2015). Whilst the long period of non-utilisation has generated significant costs (Hamilton, 2015), it nevertheless allows for another alternative source of water for the on-going drought. Interviewed in the LA Times, the city mayor states that '[W]e recognise it's a big decision to make,' and that '[W]e also recognise that desalination is not just for this particular drought – they are cyclical' (Hamilton, 2015).

Interestingly, Barnett and O'Neill also argue that large projects, such as desalination, can reduce incentives for citizens to reduce their water consumption too. This case in Santa Barbara is an interesting example in that the average per capita water consumption is already low, falling below other Southern Californian cities, and the city has been recognised for its water conservation efforts even though the plant is now being used as a 'last resort' (Hamilton, 2015).

4. Redefining maladaptation

The reviewed literature suggests that it is important to consider the intentionality behind the adaptation action leading to the

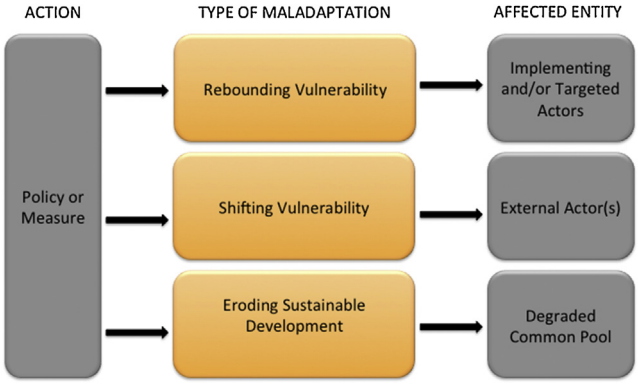

Fig. 1. Feedbacks in maladaptation.

negative outcome(s). The way maladaptation has been defined previously – i.e. by the IPCC – it covers both the outcomes of intended and unintended adaptation actions.

In order to facilitate the operationalisation, we argue that autonomous adaptation should be excluded from the analysis of maladaptive outcomes. When considered autonomous, the action is not intended to explicitly manage climate change effects, yet resulting in adaptation as by-product. If the negative outcomes of an autonomous adaptation are to be considered maladaptive, then, for instance, all outcomes of any policy decision that increase vulnerability or erode sustainable development could be considered maladaptive, which renders the concept useless because it would be impossible to set any clear system boundaries.

Based on the same logic, we further argue that maladaptation should not include so-called *avoidant adaptation actions* (e.g. Le Dang et al., 2013; Niemeyer et al., 2005) that are built on perceptions such as the denial of a threat, wishful thinking and fatalism (Grothmann and Patt, 2005: p. 203) as part of the analysis. If the concept of maladaptation is applied to denote non-action on adaptation, all action that is considered to be non-adaptation would be maladaptation. Defined as everything but adaptation, the concept loses its analytical edge and the opportunity for empirical application.

Consequently, it is important to distinguish between maladaptation and failed or unsuccessful policy implementation. An unintended outcome of an adaptation action is not necessarily maladaptive, it might just be a failed policy which does not reduce vulnerability to climate change impacts but does not achieve adaptation either. However, if the action increases vulnerability or negatively affects actors' ability to deal with climate impacts or efforts to implement sustainable development goals (economic, environmental or social), the action can be considered to be maladaptive.

Given the above, we argue that the previous definitions of maladaptation might be too encompassing to enable well-defined analyses of maladaptation. We suggest using our typology of maladaptation from the literature, which highlights three distinguished types of maladaptive outcomes: *rebounding vulnerability, shifting vulnerability and eroding sustainable development*, as a starting point to sketch out a more refined definition. We argue that the application of maladaptation as a framework requires specifying the type, aim and target audience of an adaptation action, as well as the system boundaries including geographical and temporal scale at which the outcomes are assessed. Thus, we argue that, for the concept to be relevant and applicable for analysing policy outcomes, maladaptation could be defined as:

> *a result of an intentional adaptation policy or measure directly increasing vulnerability for the targeted and/or external actor(s), and/or eroding preconditions for sustainable development by indirectly increasing society's vulnerability*

As noted in Table 1, the linkages between an adaptation action and the maladaptive outcome highlight the negative effects at several levels of the geographical scale: at local level, where the implementing/targeted actor(s) or an identified external actor are directly affected by the action; and at regional or global levels, where the common pool (such as the atmosphere, water, soil or the economy) is affected, which leads to indirect effects for all or several actors (Fig. 1).

5. Conclusion

We have explored the analytical strength and operational dimension of the concept. We argue that the potential for maladaptation as a concept is twofold. First, it has and can continue to be utilised to open up the debate on the effectiveness, equitability and appropriateness of adaptation policies and measures and the acknowledgement of their diverse effects. Towards this end, the existing definitions of maladaptation, provided by e.g. Barnett and O'Neill (2010) and the IPCC AR5, seem apt. Second, we further argue that the concept has the potential to serve as a point of departure for analysing the actual or potential negative outcomes of specific adaptation policies or measures. To achieve this, we suggest that three elements are important to consider: the specification of whether maladaptation is considered an outcome of an adaptation action or a maladaptive process, the definition of system boundaries and, finally, the identification of thresholds.

To make the concept operationally apt for these types of analyses, we suggest a refined definition of maladaptation that departs from the necessity of specifying the type, aim and target audience of an adaptation action that leads to a negative outcome, including the negative feedback loops across multiple scales.

This clarification based on our analysis and the refined definition open up a space for more analytically sound analyses of maladaptive outcomes empirically. There are also further questions that arise in terms of understanding maladaptation. For example, future research efforts could assess how the various aspects of vulnerability are affected. A departure here could be Barnett and O'Neill's (2013) recognition that some adaptive actions may generate bigger risks for maladaptation than others. Hence, adaptation actions that reduce exposure carry the biggest risk for maladaptation, those decreasing sensitivity a moderate risk, whilst building adaptive capacity is considered to be least likely to lead to maladaptation.

Whilst acknowledging the potential, we also recognise the limits of the use of the concept. The outcomes of policy actions will always be uncertain and unpredictable to a degree, making their assessment a challenge. Even successful policy outcomes are likely to have negative effects in varying degrees for some. We propose, however, that to assess the outcomes of adaptation policy and measures, a more refined definition of maladaptation is necessary. In order to develop this field further, there is a need for more research to scrutinise the new definition of maladaptation through empirical case studies, and to investigate how thresholds for maladaptation can be set in such analyses.

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